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(58) Field of search

B7B

Selected US specifications from IPC sub-classes B62D  
B60R

## (54) Load bearing structures for vehicles

(57) A reinforcement 4 is embedded in urethane 5. The structure 1 is as strong as a conventional metal only structure although the reinforcement is thinner than a conventional metal sheet structure. The structure 1 is inherently corrode resistant. The reinforcement may be in the form of metal rods, mesh, pressed metal, sheet metal or glass reinforced resin members and the structure 1 may be a side frame front side member, or door. Also described is a method of making a whole body by joining together several such structures to form a loosely assembled body reinforcement structure with a series of joints J, and moulding polyurethane foam around the body reinforcement structure to form a complete body.

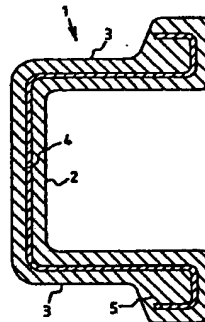


FIG. 1.

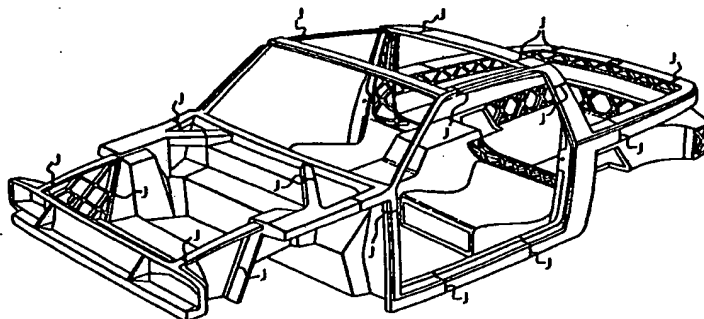


FIG. 20.

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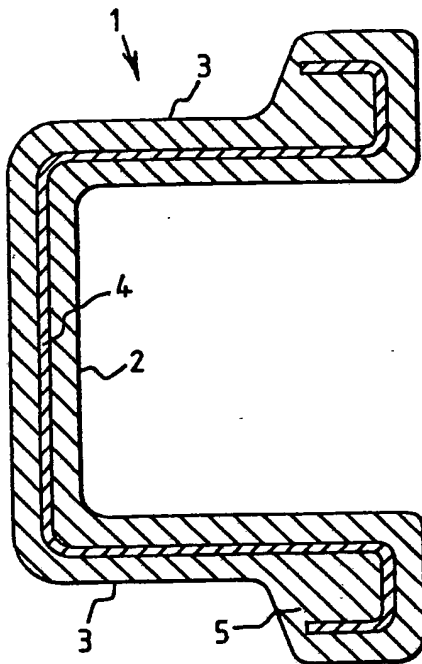


FIG. 1.

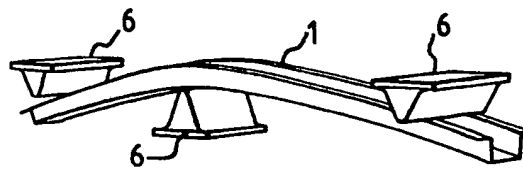


FIG. 2.

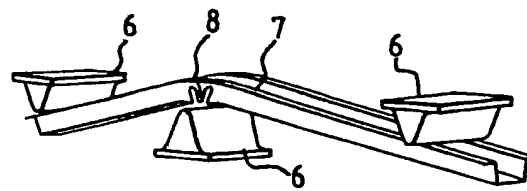


FIG. 3.

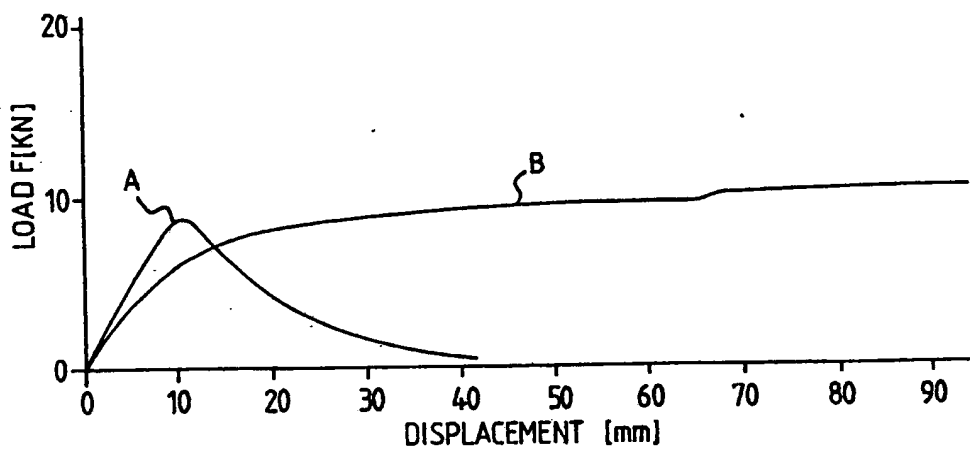
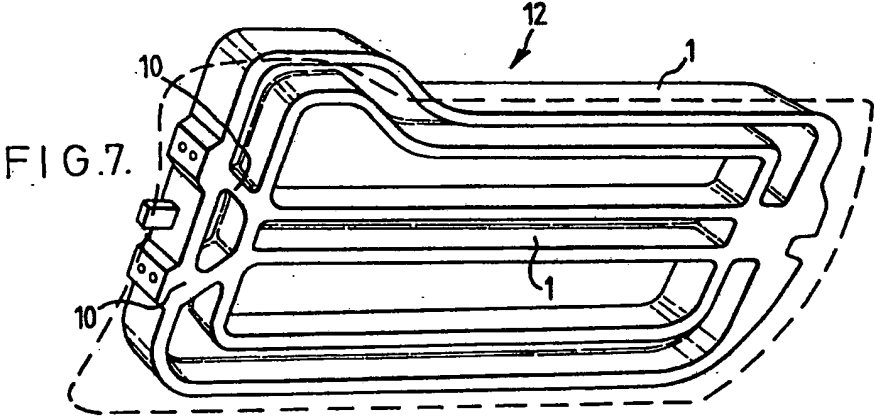
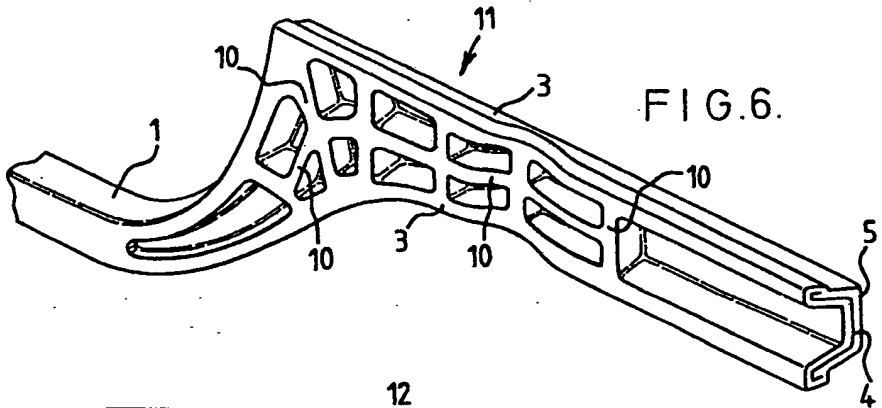
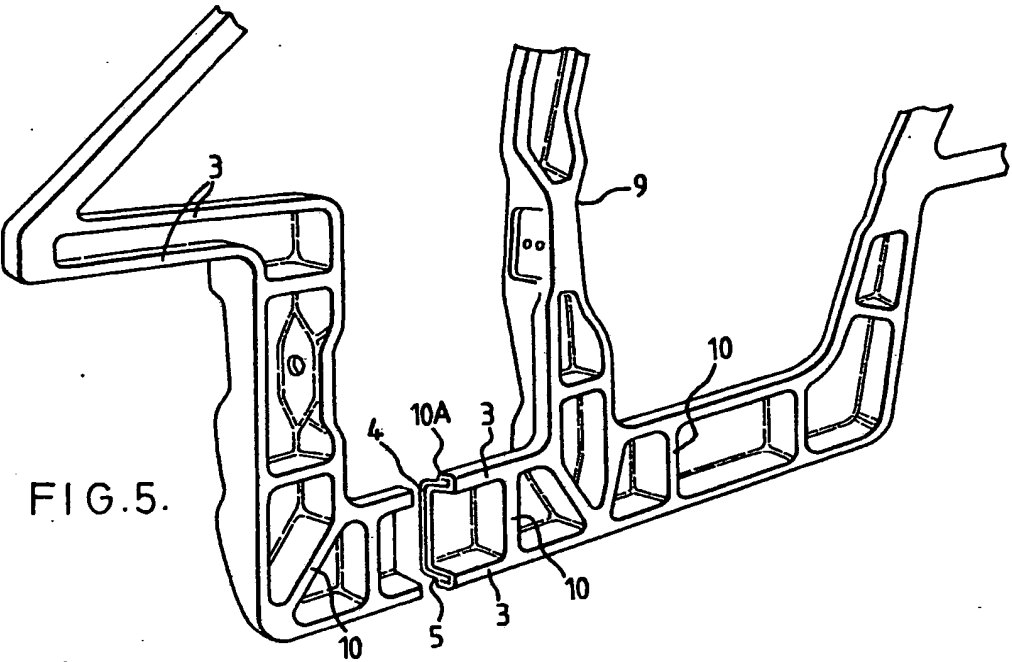


FIG. 4.



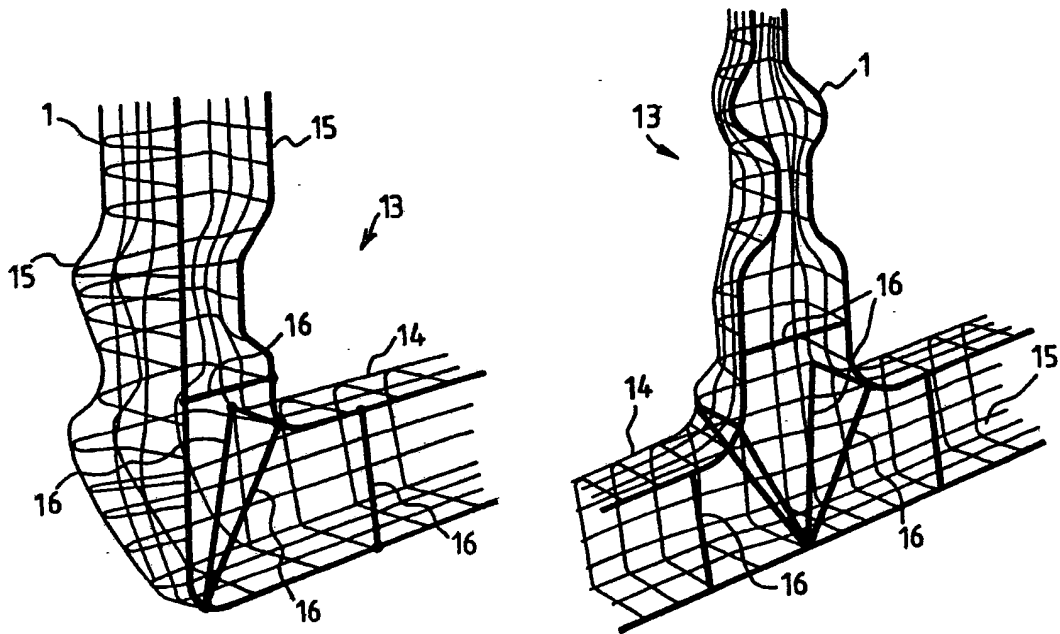


FIG. 8.

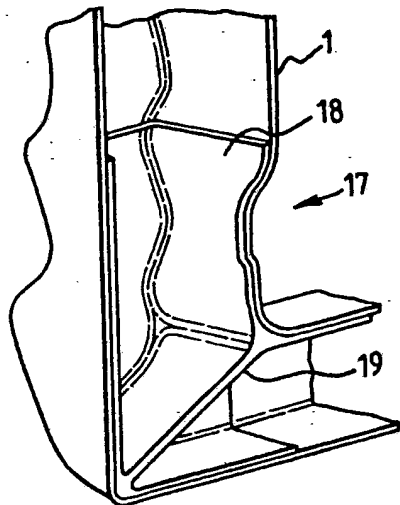


FIG. 9.

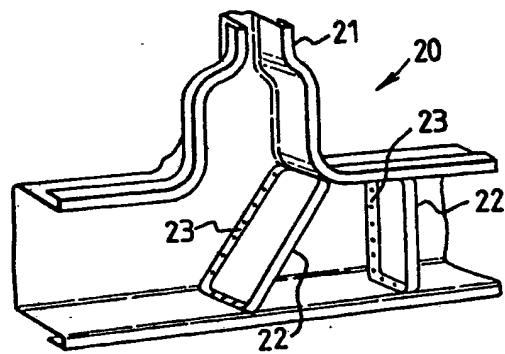


FIG. 10.

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FIG.11.

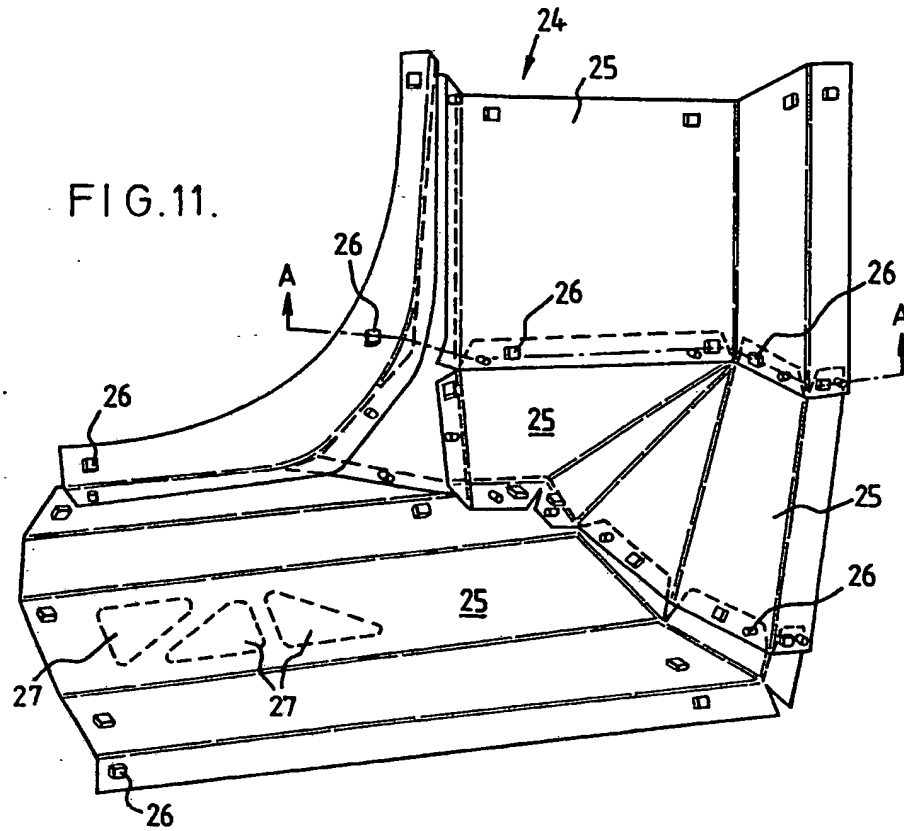


FIG.12.

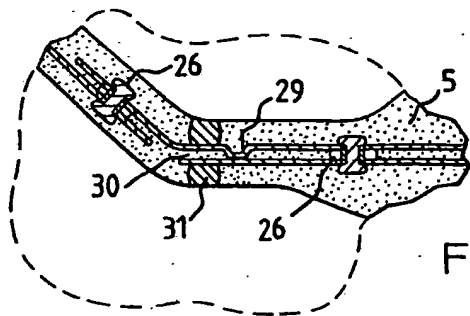
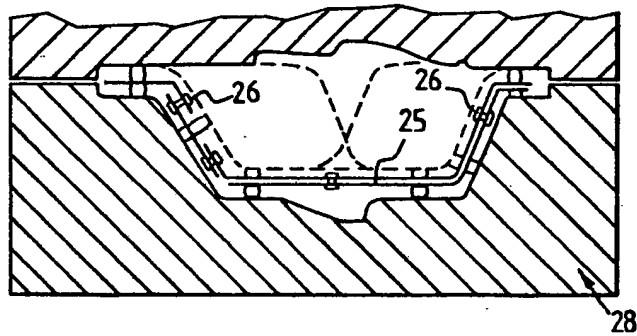


FIG.13.

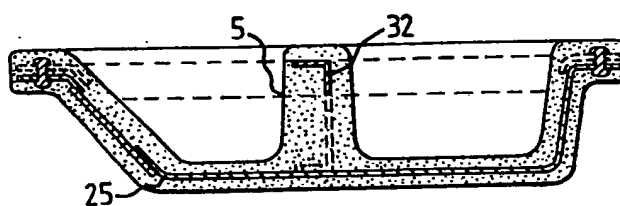
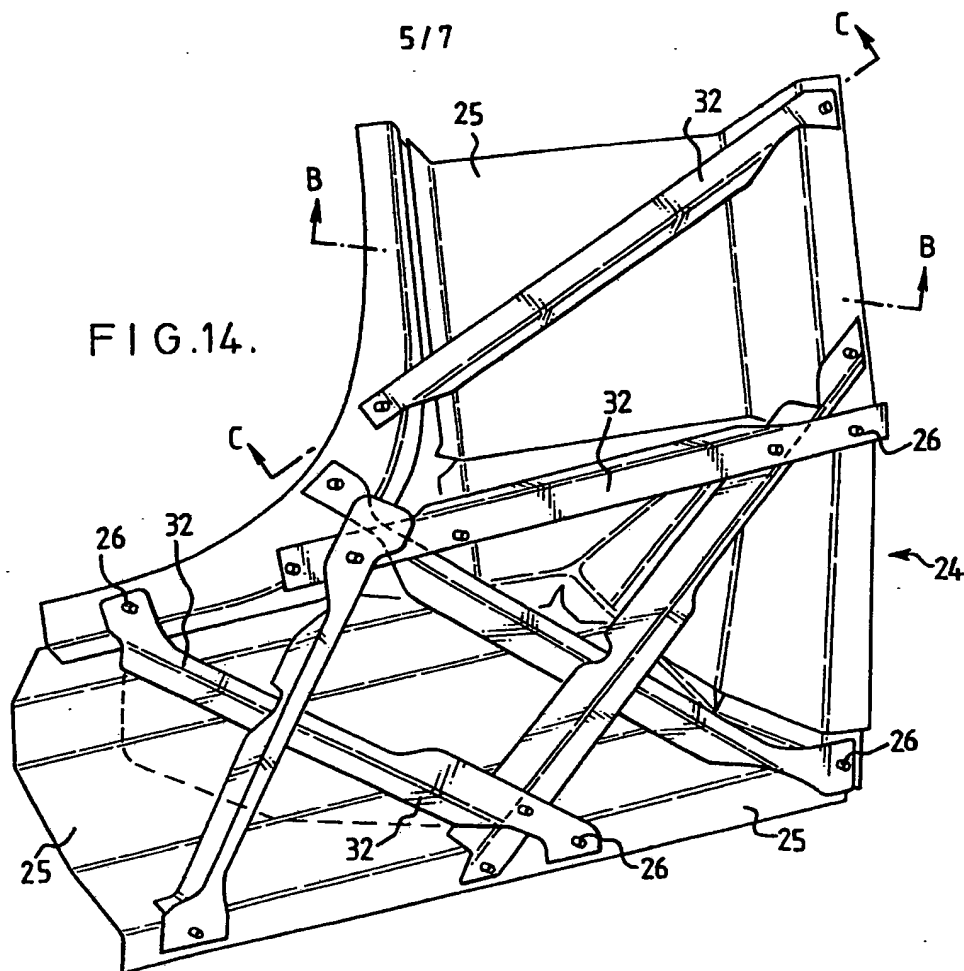


FIG. 15.

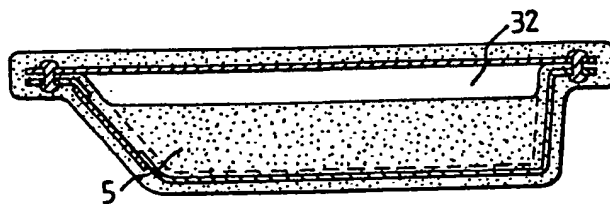
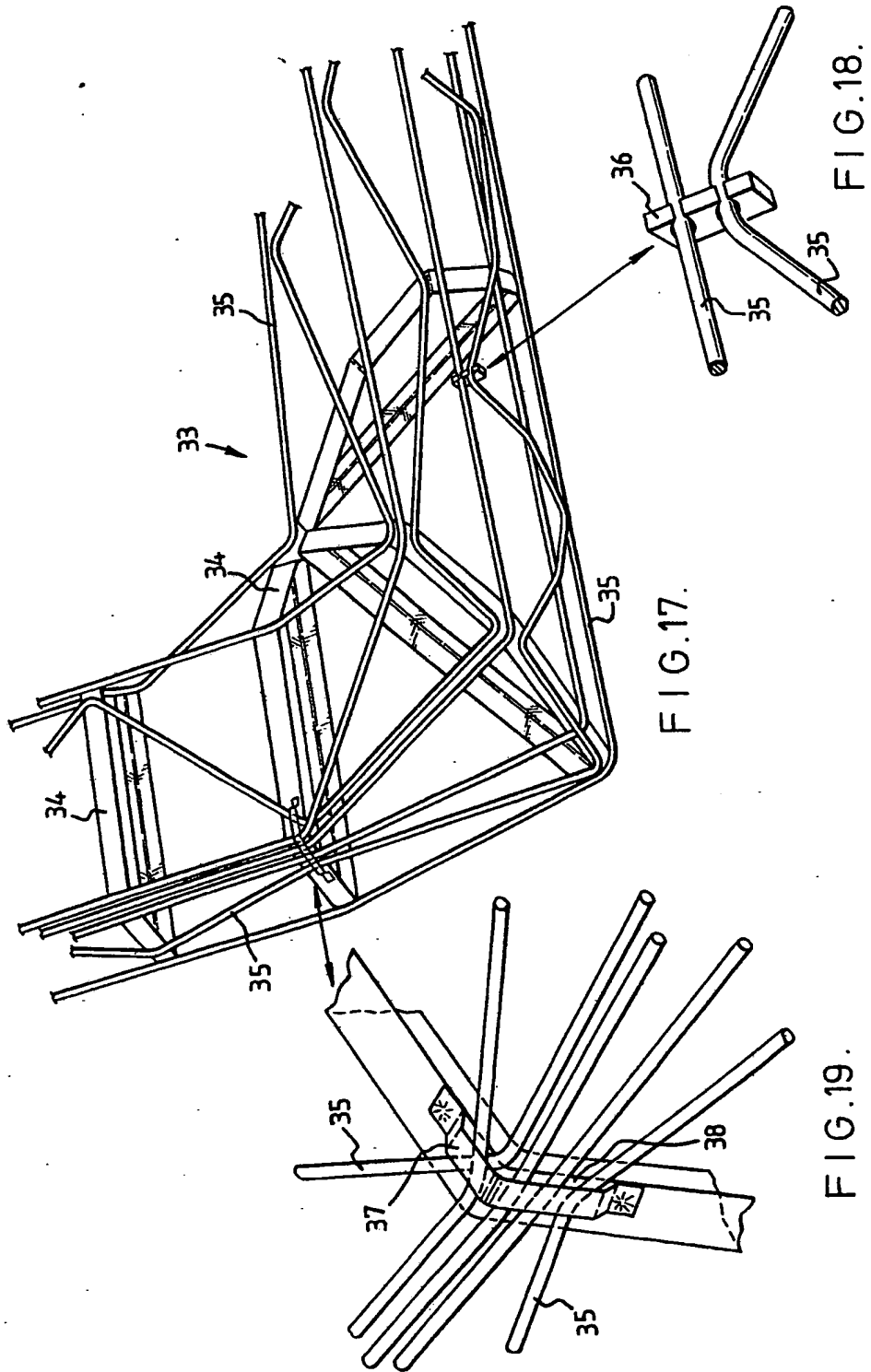


FIG. 16.

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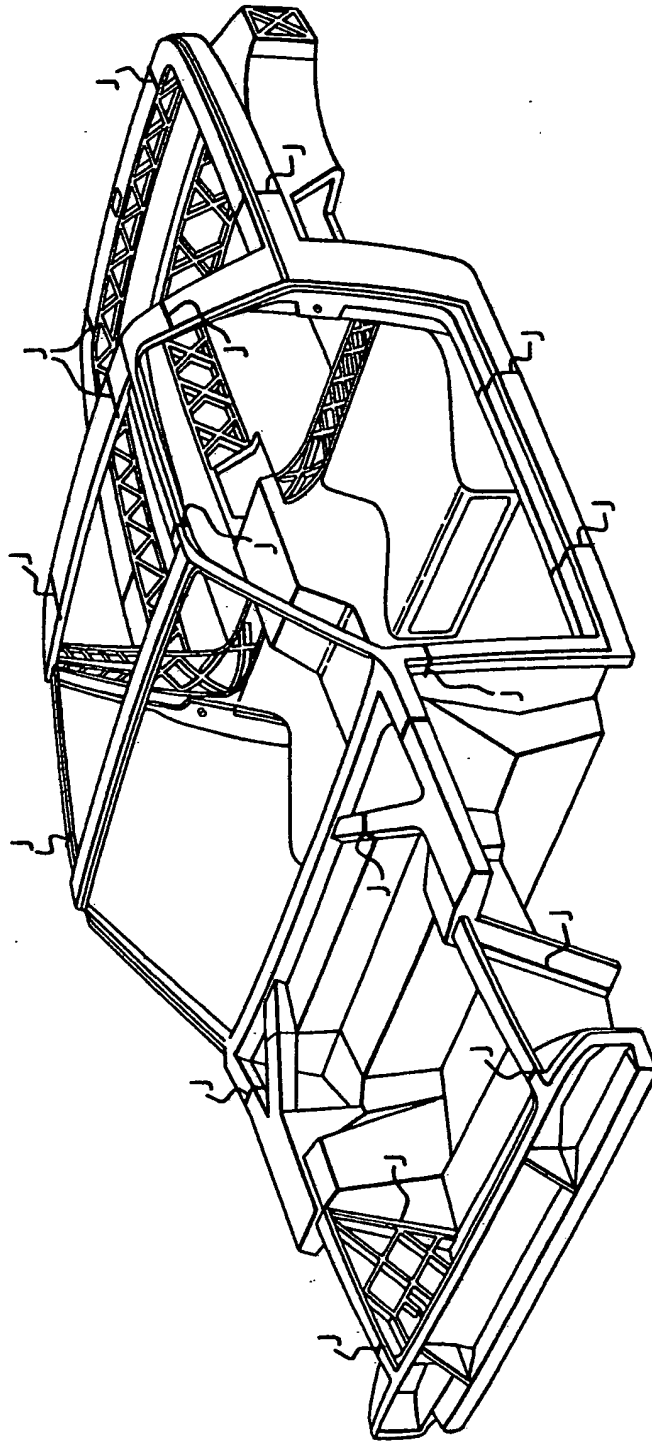


FIG. 20.

## SPECIFICATION

### Load bearing structure for vehicles

- 5 This invention relates to a load bearing structure for a vehicle.

When a thin walled metal beam is subjected to loading such as end load, bending moment or shear or a combination of any of these loads, compressive loads can arise in certain areas of the beam walls. Often, in thin walled metal beam structures, such as those used in vehicles, these compressive loads, which can be below the yield stress of the material, can result in local areas of buckling instability. This may cause premature failure of the beam and subsequent disastrous collapse of the structure, due to a local hinge forming, due to these buckles.

- 20 Structures for vehicles which comprise thin walled metal beams usually have their constituent panels joined by spot welding, such as in the joining of lengths of beams. Due to the localised nature of this type of welding some gaps between the panels are always present. The flexibility of these gaps tends to lead to movement in the joints, thus reducing the strength and stiffness of the structures.

Thin walled metal beams are usually closed box beams which are complicated to assemble and to weld. It is also costly and difficult to add reinforcing ribs to a closed box beam. For example, it is impossible to spot weld an internal diaphragm to certain internal portions of the closed box beam, due to the lack of accessibility and the difficulties in maintaining a proper fit.

Pressed metal panels require good exterior surface finishes and must meet close tolerances for good appearance, for neat fitting and for aerodynamic reasons. It is therefore expensive to manufacture such metal panels because the tooling cost is high.

Finally, metal panels are inclined to corrode if the parts are damaged in any way such as a scratch in the protecting layer of paint on the panel.

It is an object of the present invention to provide a load bearing structure for a vehicle to replace those currently widely used having superior strength and/or to overcome the aforementioned disadvantages.

According to one aspect of the present invention there is provided a load bearing structure for a vehicle comprising a skeleton of one or more reinforcement members embedded in plastics material.

The skeleton is preferably embedded in the plastics material by reaction injection moulding.

When there is more than one reinforcement member, the reinforcement members are preferably welded together to form the skeleton prior to being embedded in plastics material.

65 The reinforcement members are preferably

made from sheet steel but can also be made from any other suitable material such as from pressed or hammer formed wire mesh, or assembled lengths of wire, or from moulded plastics reinforced with Kevlar (Trade Mark) material, glass filaments or carbon filaments.

The embedding plastics material is preferably cellular urethane.

Single reinforcement members are preferably C-shaped in cross-section with a uniform thin layer of plastics material coated on each side. Reinforcement ribs also embedded in the plastics material may be positioned across each reinforcement member to add even more strength to the structure.

The reinforcement ribs are preferably welded to each reinforcement member.

According to another aspect of the present invention there is provided a method of forming a load bearing structure for a vehicle comprising forming a skeleton for the structure of one or more reinforcement members, placing the skeleton in a mould, and injecting plastics material into the mould to embed the skeleton within the plastics material.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

95 Fig. 1 is a cross-sectional view through a composite beam according to the invention;

Fig. 2 is a perspective view of the composite beam of Fig. 1 under load;

Fig. 3 is a perspective view of a thin walled metal beam under load;

Fig. 4 illustrates the load characteristics of the beams of Fig. 2 and Fig. 3;

Fig. 5 is a perspective view of a first embodiment of a structure for a vehicle according to the invention;

Fig. 6 is a perspective view of another structure according to the invention;

Fig. 7 is a perspective view of a further structure according to the invention;

Fig. 8 is a perspective view of two structures according to the invention;

Fig. 9 is a perspective view of a third embodiment of a structure according to the invention;

Fig. 10 is a perspective view of a fourth embodiment of a structure according to the invention;

Fig. 11 is a plan view of a fifth embodiment of a structure according to the invention;

Fig. 12 is a cross-sectional view along the lines A-A of Fig. 11 with the structure in a mould;

Fig. 13 is an enlarged view of a part of Fig. 12;

Fig. 14 is a plan view of a sixth embodiment of a structure according to the invention;

Fig. 15 is a cross-sectional view along the lines B-B of Fig. 14;

Fig. 16 is a cross-sectional view along the lines C-C of Fig. 14;

Fig. 17 is a plan view of a seventh embodiment of a structure according to the invention; Fig. 18 is an enlarged view of a first part of Fig. 17;

5 Fig. 19 is an enlarged view of a second part of Fig. 17; and

Fig. 20 is a perspective view of a base frame of a vehicle according to the invention.

Fig. 1 shows in cross-section a C-shaped composite beam 1 having a face 2 and two walls 3, and comprising a reinforcement member 4 or skeleton embedded in a plastics material 5. The reinforcement member 4 comprises a strip of metal which is generally C-shaped in cross-section. The plastics material 5 is made from cellular urethane which is self-skinning.

The metal reinforcement member 4 is embedded in the urethane 5 by supporting the reinforcement member 4 within a cavity of a mould. The urethane 5 fills the mould cavity by means of a reaction injection moulding process to completely encapsulate the reinforcement member 4, as described later in more detail with reference to Figs. 12 and 13.

Fig. 2 shows a composite beam 1 of Figure 1 being subjected to a lateral three point loading system 6. Fig. 3 shows a thin walled metal beam 7 being subjected to the same loading system 6. The beam 7 is of the same metal and the same general shape as the composite beam 1 of Figure 1 and of approximately the same weight indicating that the metal of the beam 7 is thicker than the metal used for the composite beam 1. Figs. 2 and 3 show that for the same displacement due to an applied load, a compressive buckle causes a failure hinge 8 to form in the thin walled beam 7 causing the beam 7 to collapse with a rapid reduction in resistance with further displacement, but no hinge forms in the composite beam 1. Hinge formation in the thin walled beam 7 may also be encouraged by local lateral deformation due to the application of the load 6.

Fig. 4 shows a typical load/displacement curve for the two beams 1 and 7. Curve A illustrates the load characteristic of the thin walled beam 7 and curve B illustrates the load characteristic of the composite beam 1. The curves show that the composite beam 1 can withstand a greater load before hinge formation 8 occurs. Thus the energy absorbed during deformation is much greater. This means that deformation will be less for a given input of energy for a structure comprising the composite beams 1.

The effect of the urethane which is on both sides of the reinforcement member 4 is to provide lateral support, by providing a resisting compressive load on the reinforcement member face 2, whichever way the member wall 3 tends to move. If the urethane were only on one side of the reinforcement member 2, then each wall 3 is free to move away

from the urethane 5 due to the inefficient tensile properties of the bond between the urethane and the reinforcement member 4. Thus the reinforcement member 4 tends to buckle at a low load and away from the internal urethane, as for a thin walled beam 7.

The other increase in efficiency which is gained by supporting the reinforcement member 4 on both sides is due to the fact that the symmetrical nature of the urethane support results in an efficient bending section being formed which resists lateral displacement of the walls 3 because of the efficient shear properties of the bond between the urethane and the reinforcement member 4.

Fig. 5 shows a structure 9 for a vehicle comprising a number of composite beams. The structure 9 is a component for a car body known as the side frame. The structure 9 can be moulded in one piece or it can be manufactured from a number of moulded pieces which are joined together. Reinforcement ribs 10 are moulded integrally between the walls 3 of the composite beams. A cross-section through one of the composite beams 10A shows a reinforcement member 4 embedded in the supporting urethane 5.

Fig. 6 shows another composite beam structure 11 which is a component for a car body known as the front side member which has been moulded in one piece. The beam has a metal reinforcement member 4 forming a skeleton running the length of the structure 11 embedded in urethane 5, with reinforcement ribs 10 arranged within the walls 3 of the beam 1.

Fig. 7 shows a further structure 12 which is a framework for a car door, which has been moulded in one piece. The structure 12 comprises an outer composite beam 1 having reinforcement ribs 10 and an inner transverse composite beam 1 each with a metal member extending along its length and embedded in urethane.

Fig. 8 shows an embodiment in which composite beams comprise a reinforcement member 15 made from wire mesh 14 which is manufactured into the form of an open beam. Reinforcement ribs 16 are provided by wire rods which are either welded or mechanically attached to the wire mesh 14. The mesh 14 and ribs 16 form a skeleton which is then embedded in plastics material (not shown) in a mould by reaction injection moulding.

Fig. 9 shows an embodiment of the structure in which a composite beam 1 comprises a reinforcement member 18 forming a skeleton made from moulded plastics material reinforced with woven glass filaments. A reinforcement rib 19 made from the same material as the reinforcement member 18 is shaped to fit within the reinforcement member 18. The reinforcement rib 19 is bonded to the member 18 during the moulding process when embedding urethane is applied to the outer

surfaces of the member 18 and the rib 19 due to the adherence and inherent supporting urethane material.

Fig. 10 shows another embodiment of a structure in which the composite beam comprises a reinforcement member 21 made from pressed metal. Reinforcement ribs 22 are also made from pressed metal having flanges 23 and spot welded at the flanges 23 to the inside of the open beam structure 20. The reinforcement ribs 22 do not have to be welded along the whole length of the flanges 23 because the supporting embedding plastics material (not shown) provides enough strength to hold the reinforcement ribs 22 to the reinforcement member 21 after moulding.

Any of the reinforcement members hereinbefore described may be stiffened or reinforced with bonded on or mechanically attached metal, wire or tape made from glass, carbon fibre or the like.

Fig. 11 shows a further embodiment of a structure comprising a panel 24 assembled from folded, pressed or pre-moulded sheets of metal 25 which are held together by means of rivets 26, which are either fitted with the panel 24 on an assembly jig or with the panel 24 in a mould. Triangular-shaped apertures 27 are provided in the panel 24 to reduce its weight. The sheets of metal 25 need not be machine finished, and preferably have roughened surfaces and edges to provide a good bond between the sheets of metal 25 and the urethane 5 to be added which is applied as before by injection moulding.

Fig. 12 shows the panel 24 in cross-section taken along the line A-A. The panel 24 is shown in position within a mould 28.

Fig. 13 shows a part of the panel 24 enlarged. Indentations 29 are provided in the sheets of metal 25 to hold the adjacent metal sheets apart and provide gaps 30 between the sheets of metal 25. Spacers 31 are provided to position the panel 24 within the mould 26. After the top half of the mould 26 is placed over the panel, urethane 5 is injected in the mould 26 to fill the gaps 30 and to completely coat the panel 24. The sheets of metal 25 become bonded together by the urethane 5 which prevents any movement between the sheets 25, thus preventing any metal fatigue.

Fig. 14 shows another embodiment of a structure using the panel 24 of Fig. 11. In this embodiment reinforcement members 32 are rivetted onto the sheets of metal 25 to provide additional support to the panel 24.

Figs 15 and 16 show the panel 24 in cross-section taken along the line B-B and the line C-C respectively, after the panel 24 has been embedded in urethane 5.

Fig. 17 shows an embodiment of a structure 33 comprising a framework made from folded strips of metal 34 and reinforcement members made from rods 35. The rods 35

form a lattice to help to reinforce the structure 33.

Fig. 18 shows how the rods are loosely connected together by connector blocks 36 made from a resilient plastics material, which allows the rods 35 to be snap-fitted into position at the intersection of two or more rods 35.

Fig. 19 shows how the rods are attached to the folded strips of metal 34, by a thin strip of metal 37 which is welded at its ends to the folded strips of metal 34, providing a slotted aperture 38 through which the rods extend. The structure is completed by positioning the structure 33 forming a skeleton in a suitably shaped mould and injecting urethane material into the mould which adheres to all the outer surface of the strips 34 and rods 35.

The single purpose load bearing structures so far described can be joined together to form more complex or multiple structures. Preferably, the ends of each structure, or where required intermediate parts of the structures, are provided with protruding metal tags. When joints are to be made the respective tags are brought and fixed together by spot welding or the like and the joint surrounded by a mould. The mould is then filled with plastics material by injection moulding techniques and once the plastics has set, the mould is removed. As a result a permanent joint is formed holding the two or more structures together in a chosen relative configuration.

The ends of the structures can also be suitably shaped externally so as to fit together at least loosely, in the manner of fitting jig-saw parts for example. Thus, the parts are held in a correct configuration in a mould prior to the egress of plastics material into the mould positioned around the joint.

In this way a vehicle frame or chassis can be provided using the described structures of various shapes and sizes as may be required.

Fig. 20 shows the base frame or chassis of a vehicle comprising several load bearing structures of the kinds described above which are joined together at the reference points J.

The structures are provided with a metal tags at each joint. The tags are bolted, welded or otherwise fixed together and each joint is embedded in urethane by injection moulding. By encapsulating each joint the joint between the connecting tags is reinforced and also protected against corrosion. Parts of the base frame may also be provided with conventional load bearing structures. The conventional structures also have tags for connection to the tags of the urethane coated structures. Also, each joint may be provided by snap fitting interconnecting members. The joint is then reinforced by addition of urethane or a suitable adhesive such as cyanoacrylate while being held in a suitable jig or mould.

The described composite beam structures provides several benefits compared to conventional metal structures for vehicles, including:

- 5 providing a stronger structure weight-for-weight which is safer when subjected to a given amount of energy, for example, during impact in an accident;
- improving the strength of the connections between the component members which make up a structure;
- 10 the structures do not corrode;
- enabling simpler placement of additional reinforcement members in open beam sections for example, which is done before moulding and which reinforcement members can be temporarily placed prior to being fixed by the moulded urethane;
- 15 reinforcement members can be readily added to the structure as and where required;
- 20 allowing greater tolerances to be acceptable for the metal components of the structure which reduces tooling costs;
- the exterior shape of the structure is provided by the surface of the plastics material which is easier and cheaper to provide by moulding than by careful pre-forming or post-manufacture finishing;
- 25 the structure is less susceptible to local deformation at points of application of loads;
- 30 the structures may be connected using metal tags, to an adjacent structure to build up the frame of a vehicle; and
- the structure may be connected to conventional load bearing structures at points where additional strength is required in the frame of a vehicle.

It will be noted that the embodiments of the invention enable a long standing difficulty relating to vehicle manufacture to be overcome. For many years and especially since body parts have also been made to provide structural strength and maximum safety for vehicle occupants, the parts have traditionally been made of sheet metal. It has already been mentioned that it is difficult to introduce bracing members especially in box-like structural members at particular points of need. This is rendered simple in the structures described. However, the main advantages reside in being able to design and implement structures of precise strengths, shapes and characteristics.

It is appreciated that conventional vehicle metal structural parts are much stronger in tension than required but if their cross-sectional area was reduced, their strength in compression or more particularly their buckling strength falls off dramatically. Tensile strength is a function of area but buckling strength is a function of the cube of the area. Thus in an attempt to save material costs and to reduce the weight of a vehicle it is necessary to reduce the gauge of metal used, but to maintain adequate buckling strength a box-shaped structure must be used or strengthened ribs and cross members must be added making

manufacture more complex and in some cases introducing unreliability.

Embodiments of the invention provide a most useful and acceptable solution. The metal gauge is reduced and the buckling strength primarily maintained by coating the metal or other suitable reinforcement members with plastics material. Typically the gauge of the reinforcement members 4 in Fig. 1 for example is reduced to 0.5mm and coated with urethane 10mm thick. (The wires used in Fig. 8 for example are 3 to 4mm in diameter). Although the buckling strength of urethane is of the order of 1/250 of steel, the structures formed in the manner described above have an overall buckle strength comparative to that of sheet metal of 1mm thick.

Thus, the structures provided by the invention are no less strong than conventional vehicle parts currently used. Further, there is no weight penalty and the structures formed are not prone to corrosion as the metal parts are totally embedded. Added to that, the external finish of the structures can be of a very high standard being controlled by the mould surfaces and thus requiring little or no post-assembly finishing. The reinforcement metal members, some of which traditionally form the external vehicle surfaces, are currently manufactured in expensive metal presses which adds significantly to the cost of vehicle manufacture. The reinforcement members used in the present invention by contrast can be roughly finished, and in some cases are preferably provided with uneven surfaces, and are so much cheaper to produce. As described in Fig. 20 the vehicle chassis can be made from a number of structures joined together. The joints are formed by plastics moulding techniques reducing the cost of significantly as comparably to using jigs and presses, and the joint needs no or virtually not post-jointing finishing, before painting for example where desired.

#### 110 CLAIMS

1. A load bearing structure for a vehicle comprising a skeleton of one or more reinforcement members embedded in plastics material.

2. A structure according to claim 1, in which the skeleton is embedded in plastics material by reaction injection moulding.

3. A structure according to claim 1 or 2, in which the skeleton is formed by welding reinforcement members together.

4. A structure according to any of claims 1 to 3, in which the reinforcement members are made from steel.

5. A structure according to claims any of 1 to 3 in which the reinforcement members are made up into a metal lattice structure.

6. A structure according to any of claims 1 to 4, in which the reinforcement member or members are C-shaped metal beams coated

on both sides with plastics material.

7. A structure according to claim 6, in which the reinforcement members are provided with ribs tacked or otherwise held in position to the reinforcement members and embedded in the plastics material.

8. A structure according to any of claims 1 to 7 in which the plastics material is cellular urethane.

9. A method of forming a load bearing structure for a vehicle forming a skeleton for the structure of one or more reinforcement members, placing the skeleton in a mould, and injecting plastics material into the mould to embed the skeleton within the plastics material.

10. A composite structure for a vehicle comprising two or more load bearing structures according to any of claim 1 to 9 joined together by injection moulding around joints formed between the structures.

11. A structure substantially as hereinbefore described with reference to any one or more of Figures 1 to 2 and Figures 5 to 19 of the accompanying drawings.

12. A frame for a vehicle substantially as herein described with reference to Fig. 20 of the accompanying drawings.